Proposal for BDDM – Drilled Shaft Loads

Prepared by Craig Shike, October 27, 2009

Modify Section 1.1.5.5 as follows:

1.1.5.5 Drilled Shafts - (continued)

(12) Shaft Reinforcement – Detail shaft reinforcing to minimize congestion and facilitate concrete placement. Space both longitudinal and transverse reinforcement to provide 5" minimum and 9" maximum openings between bars. Transverse shaft reinforcement in the non-contact splice region may be reduced to 3" minimum openings between bars. Transverse shaft reinforcement may include spiral bars, hoops and/or bundled pairs.

The moment to be transferred from the column to the top of shaft is the lesser of the overstrength plastic moment (M_{po}) of the column or the elastic seismic moment of the column. Note that the maximum shaft moment will depend on the soil-structure interaction and will generally be larger than the top of shaft moment. Determine the overstrength plastic moment of column using moment-curvature analysis as described in Section 8.5 of the AASHTO Guide Specifications for LRFD Seismic Bridge Design.

Design shaft transverse reinforcement for the lesser of the plastic shear or elastic seismic shear of the column. Since the shaft diameter must exceed the column diameter, the shaft essentially remains elastic under seismic loads. Therefore, there is no need to satisfy the volumetric ratio and spacing requirements for transverse reinforcement in LRFD article 5.13.4.6.3.

As well as meeting plastic shear or seismic shear demands, ensure shaft transverse reinforcement within the non-contact splice region meets the following maximum spacing:

$$S_{tr} = (2 * \pi * A_{sp} * f_{ytr} * 1.5 * L_{db}) / (A_l * f_{ul})$$

Where:

S_{tr} = Maximum spacing of transverse shaft reinforcement (in)
A_{sp} = Area of transverse shaft reinforcement (in^2)
f_{ytr} = Yield strength of transverse shaft reinforcement. Use 60 ksi.
L_{db} = Basic tension development length of column vertical bars (in)
A_l = Total area of column vertical bars (in^2)
f_{ul} = Ultimate strength of column longitudinal reinforcement. Use 80 ksi.

The equation above ensures the transverse reinforcement is adequate in order to fully develop the column reinforcing bars. Derivation of this equation can be found in the WSDOT report WS-RD-417.1 "Noncontact Lap Splices in Bridge Column-Shaft Connections". For column sizes 6 ft diameter and greater, #7 or larger welded hoops will likely be needed to meet both the equation above and the minimum 3" opening for transverse shaft reinforcement in the splice region.

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Background

Existing BDDM language implies drilled shaft moment at the top of the shaft do not change with depth. Proper design of drilled shafts generally results in increasing shaft moment with depth near the top of the shaft as shaft loads are transferred to soil.

Existing language has also been revised to match the seismic guide specs.